4DCT co-synchronized to real-time dynamic MRI

Damien Dasnoy[1], Benoît Macq[1]

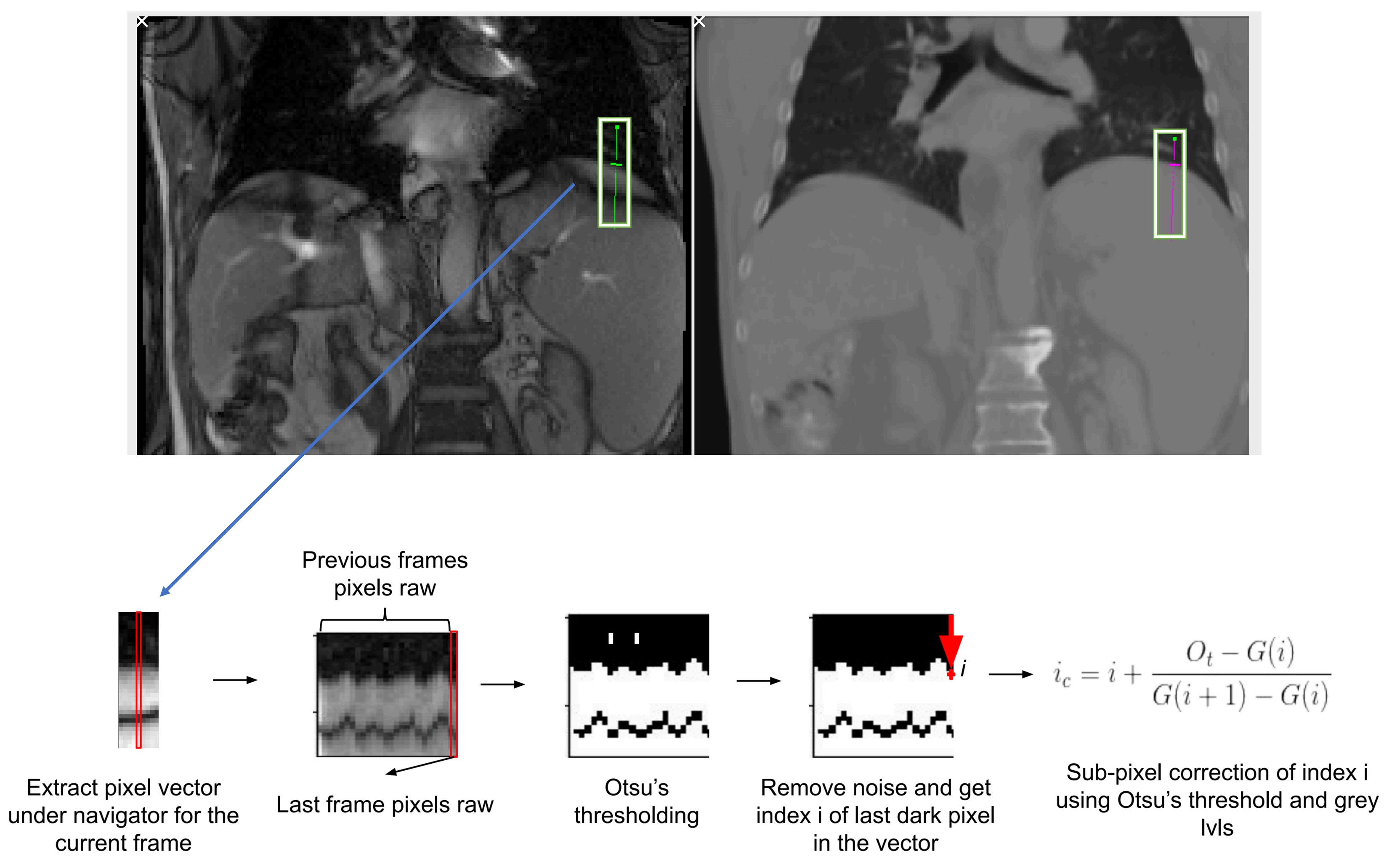
1 *ICTEAM Institute, UCLouvain, Belgium.*

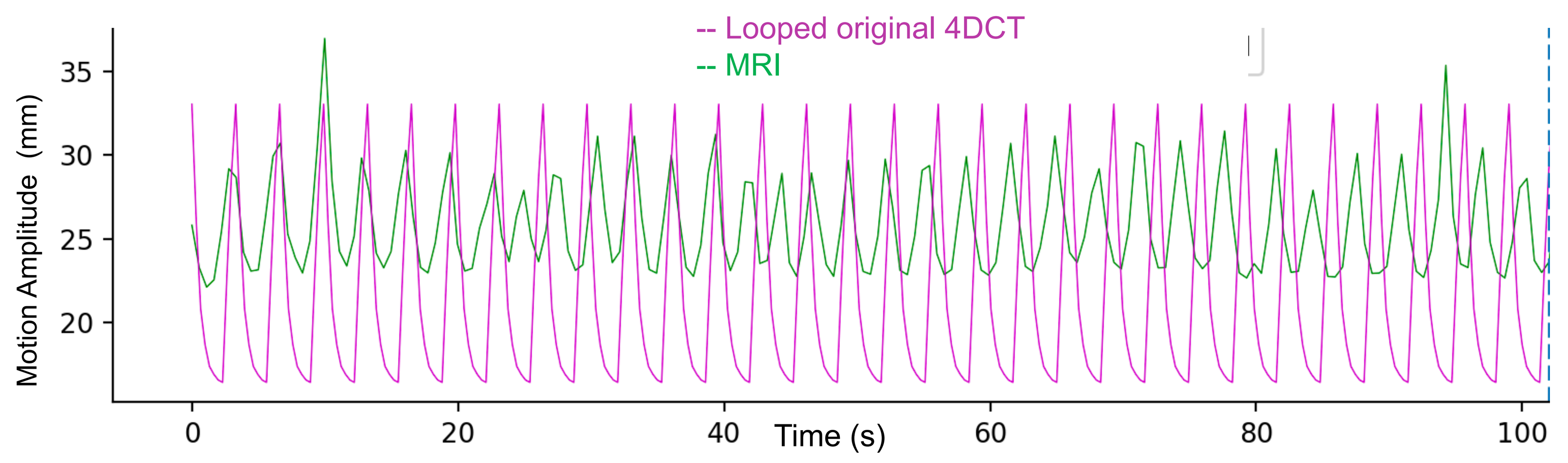
Highlight

With the arrival of hybrid Photon-MRI solutions in standard radiotherapy, real-time adaptive treatment or treatment verification are on the way. In proton therapy, the hardware solution doesn't exist yet but is under serious consideration [1-2]. While MR images can be acquired online, X-Ray type images are still necessary to plan the treatment and to compute the delivered dose. In this context, we developed a tool to transfer in real time the motion observed continuously on a dynamic 2D MRI sequence on a new set of 3DCT images, creating a continuous 4DCTc which follows the patient's breathing pattern and can be used for treatment dose computation.

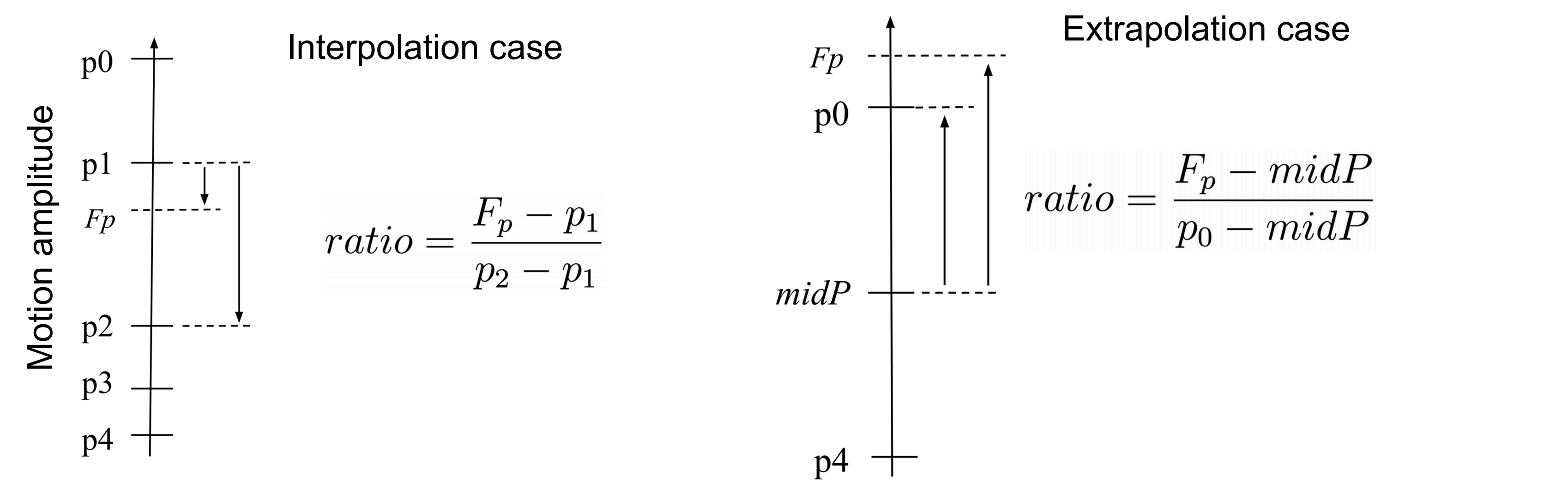
Materials and Methods

1. Tracking of borders which are visible on both MR and CT modalities based on manually placed navigators.



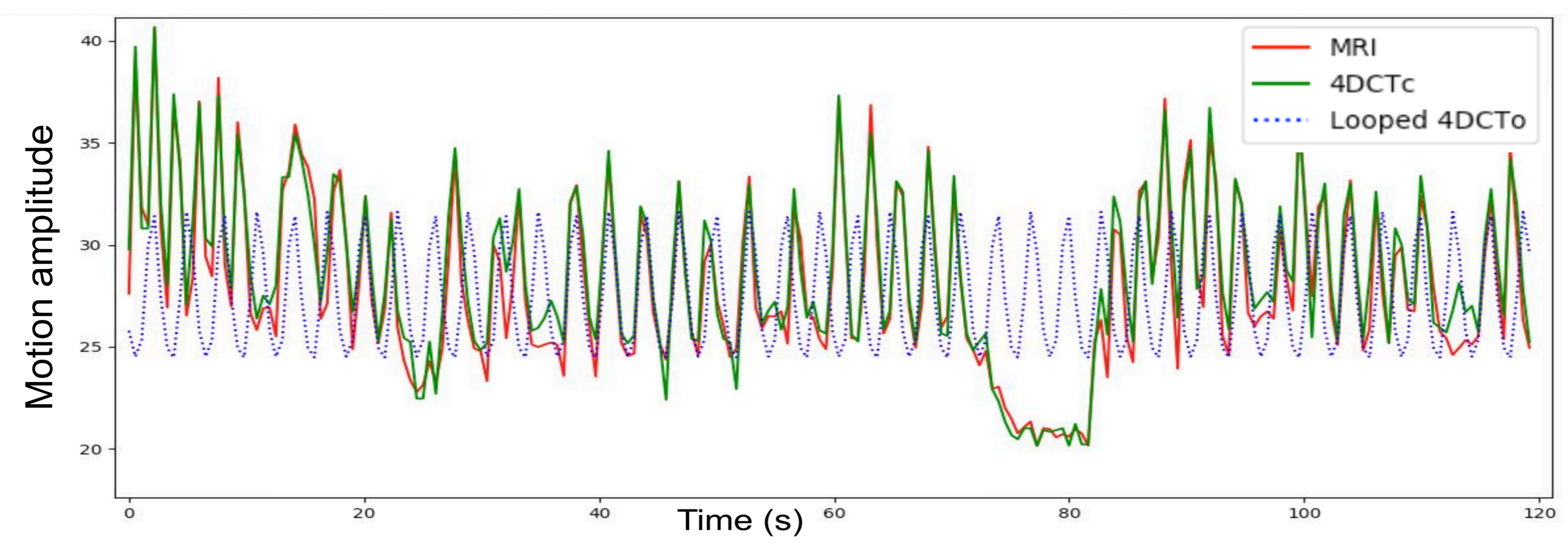


2. Interpolation or extrapolation ratio computation for each MRI frame.
- First, the measured amplitude on the MRI is compared to the amplitudes measured on the 10 phases of the original 4DCT for the same position in the anatomy.
- Then, a ratio is computed using differences in measured amplitudes. If the MRI position *Fp* is outside the 4DCT range, the motion will need to be extrapolated and the *midP* phase is used (A phase which represent the mean of the 10 images of the 4DCT.)



3. The precomputed deformation field is multiplied by the computed ratio and the corresponding 3DCT image is created and added to the continuous 4DCTc image set.

4. The motion is tracked again on the newly created image to control the results in real time.



Results & Discussions

The motion contained in the created 4DCTc sequence is a lot closer to the MRI motion than simply using the original looped 4DCT, with a mean border position difference under 2mm. The manual selection of the tracked borders is useful to avoid artefacts in both MR and CT modalities, and to be able to chose an anatomical region which moves as similar as possible as the tumor. As the original 4DCT deformation fields are used to describe the motion, our method relies on the assumption that the anatomical motion is mainly correlated to the breathing amplitude and that the same correlation is still valid on the treatment day. A new 4DCT could be created for each treatment day using for example 4DMRI [3] to reduce the potential inter-fraction error. The motion of borders which were not used to create the 4DCTc can be tracked afterwards to evaluate the quality of the reproduced motion in 3D and not only on the navigator's position.

Conclusions

The full 3D motion can be reproduced with high accuracy continuously during a dynamic MRI acquisition, which can then be used to recompute the delivered dose with more precision than the original plan based on the original 4DCT.

Contact for information: Damien Dasnoy
E. mail: damien.dasnoy@uclouvain.be

References

[1] - Oborn B et al, (2015). Proton beam deflection in MRI fields: Implications for MRI-guided proton therapy. Medical Physics 2015 vol: 42 (5) pp: 2113-2124

[2] - Hartman J et al, (2015). Dosimetric feasibility of intensity modulated proton therapy in a transverse magnetic field of 1.5 T. Phys. Med. Biol, 60.

[3] - Boye, Dirk, Tony Lomax, and Antje Knopf. "Mapping motion from 4D-MRI to 3D-CT for use in 4D dose calculations: A technical feasibility study." *Medical physics* 40.6Part1 (2013).